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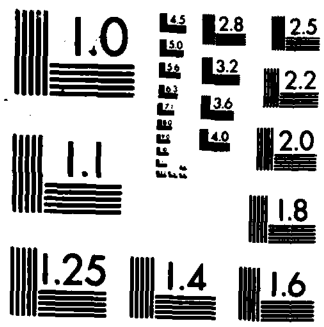

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USAFOEHL REPORT

86-077EQ0112JPD

LORING AFB WATER PLANT SURVEY
LORING AFB ME

ROBERT D. BINOVI, MAJOR, USAF, BSC

September 1986

Final Report

USAF Occupational and Environmental Health Laboratory
Aerospace Medical Division (AFSC)
Brooks Air Force Base, Texas 78235-5501

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The USAFOEHL conducted an on site survey of the Loring AFB water plant to determine coagulation efficiency. Jar testing was performed to determine optimum coagulant dosage. A survey to assess the hydraulic mixing and coagulation parameters of the pump discharge piping and flocculation basin was also performed. The plant was operating without functioning flocculation paddles. Results of calculations indicate the long residence time of the water in the flocculation basin causes the basin to be effective during the summer and marginally effective during the winter. The plant operators were adding coagulants at concentrations within the optimum range as determined by jar testing. Recommendations are: The base bioenvironmental engineer, in cooperation with water plant personnel perform jar testing monthly, repair the flocculation paddles; and (3) initiate a plan for an alternate groundwater supply.

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CONTENTS

I. INTRODUCTION

USAF Hospital Loring/SGPB requested an efficiency study of the alum addition process in a 30 Jan 86 letter indorsed by HQ SAC/SGPB. The survey was conducted from 24-26 June 86 by Major Robert D. Binovi and A1C Roberto Rolon, USAF Occupational and Environmental Health Laboratory, Environmental Quality Branch.

II. BACKGROUND

Loring AFB is located on the northeastern tip of the State of Maine within a few miles of the Canadian border. Located in Aroostook County, within the town limits of Limestone, Maine, Loring AFB is the home of the 42nd Bombardment Wing. Base population is nearly 13,000.

The primary source of drinking water for the base is the Little Madawaska River. An impoundment dam and water plant were built in 1953. The river could support the withdrawal of 10 million gallons per day (MGD). The plant capacity is about 2 MGD. Water is collected, flocculated with alum and polymer, and passed through a rapid sand filter. The water is fluoridated, chlorinated, and pumped to the base, about five miles away.

Although designed for alum addition, alum had been discontinued during the 1970s in favor of prechlorination, polymer addition, and precoating the sand filters. Prechlorination of the colored surface water provided the ideal conditions for the formation of trihalomethanes (THM). Chlorine also had caused corrosion in the flocculation basin ultimately stopping the paddles from turning.

With the advent of routine THM testing and the discovery of high THM concentrations at certain times of the year, prechlorination was discontinued, and alum and a polymer coagulant aid addition capability was installed.

Liquid alum and polymer are injected into the discharge side of the main pumps, and are mixed by the turbulence in the pipes. Flocculation occurs as the mixture passes through the obstructions (baffles, paddles) in the first flocculation chamber. The floc settles in the second chamber or is filtered out by the sand filters.

III. PROCEDURES

A. Jar testing was performed using two Phipps Bird apparatus, Hach 1100 turbidity meter, and an Orion pH meter. The jar test is a test designed to simulate the operation of the rapid mix, flocculation action of the paddles, and quiescent settling. Procedures for conducting jar testing are flexible and a procedure used by waterplant personnel, based on the plant configuration, was adopted. This procedure is as follows:

1. Fill six jars from a large container (>10 gals) with 1000 mL of untreated raw water, allow for one control, five jars with varying concentrations of coagulant.

2. Add coagulants to 1000 mLs and rapid mix at 40 rpm for 10 minutes.

3. Slow the apparatus to 13 rpm for 15 minutes to form floc.

4. Turn stirrers off, allow the floc to settle for 15 minutes.

5. Record temperature, pH, and turbidity.

The alum, chemical formulation, $Al_2(SO_4).18H_2O$, was obtained from Mallinckrodt Chemical Co. The polymer, Nalco 8100, was obtained from the water plant's supply.

B. A survey was conducted in a flocculation basin which had been drained for maintenance. The survey involved inspection and measurement of the chamber, paddles, and baffles.

IV. RESULTS AND DISCUSSIONS

A. Flocculation and Mixing Efficiency

1. The results of calculations made from the measurements in the flocculation basin indicate the long residence time of the water in the basin (>2 *hrs*) causes the basin to be effective for flocculation during the summer and marginally effective during the winter, without revolving flocculation paddles. The value of Gt, the dimensionless measure of conjunction opportunity, is 16,300 for winter (32°F), and 20,700 for summer (70°F).

The conjunction opportunity, Gt, is the product of the velocity gradient, G (sec EXP-1) and the residence time, T (sec). (1)

$$Gt = GT$$

The velocity gradient, G, is the square root of the work, W, and the dynamic viscosity, u.

$$G = (W / u) \text{ EXP-2}$$

and W in this case is equal to the useful power input, P, divided by the volume of the tank.

$$W = (P / V)$$

Flocculation basins that operate without rotating paddles can be said to function like baffled channel basins. For baffled channel basins, P is equal to the product of the rate of flow, Q, the weight density of water, pg, and the headloss, h, through the structure.

$$P = Q\rho gh \quad (2)$$

Headloss, h for baffles in turbulent flow can be computed by: (3)

h = 2 n (v EXP2 / 2 gc)

where n is the number of baffles in series, v is the velocity through the baffle opening, and gc is a dimensional gravitational constant.

Total headloss in the flocculation basin totaling the headloss due to the two baffle walls, the paddles, and the water course turn, was found to be 0.02 feet.

The useful power input P was calculated to be equal to 4.30 foot pounds/sec.

The G values for 32°F and 70°F were 2.04 and 2.6, respectively.

The alum and polymeric coagulants are injected into the discharge side of the 1550 gpm intake pumps, driven by 7.5 horsepower motors. Good mixing is provided by this system, as G values for 32°F and 70°F were calculated at 1200 and 1500 sec EXP-1.

B. Jar Testing - Coagulation Efficiency Study

The results of the jar testing are shown in Table 1, and summarized graphically in Figure 1.

V. OBSERVATIONS AND CONCLUSIONS

A. The river level was unusually low from lack of precipitation during the winter and spring. River turbidity was higher than normal. Water quality dropped significantly. The base drinking water had a distinctive "humic" taste.

B. Generally, the water plant operators were operating the plant within the optimum coagulant dosages shown by the jar tests. Efficient turbidity reduction was shown to take place with polymer dosage reduced by a factor of ten. The optimum dosage observed for the period of the survey was from 50-75 mg/L alum and 0.3 mg/L polymer.

C. Flocculation occurs when Gt values are in the range of 10,000-100,000. Normal ranges of G in flocculation basins are 10-75 sec-1. (4) Calculated Gts at the water plant (16,300, 20,700) indicated that floc forms because of the long residence time in the flocculation basin (133 min) despite the low values of G (2.0, 2.6). The flocculation basins are functioning like baffled channel basins, however, there is insufficient baffling. Better floc formation (larger, heavier) would result if the flocculation paddles were repaired, since G would be increased well into the design range.

D. Mixers normally operate at G values between 800-1000 sec EXP-1. The pump turbulence mixes polymer and coagulant well, according to the G calculation indicating velocity gradients of 1200 and 1500 sec EXP-1 resulted.

VI. RECOMMENDATIONS

A. The base bioenvironmental engineer in cooperation with water plant personnel should monitor coagulant addition by performing monthly jar testing, monitoring turbidity, pH, and temperature, while varying alum and polymer dosage. This will help determine the effect of seasonal variation on chemical dosage and optimize chemical dosage.

B. Repair the flocculation paddles. Repairing the flocculation paddles would enable larger floc to form, resulting in more efficient use of coagulant, better treatment, and better quality water.

C. To alleviate the taste problem associated with organics from the river, and reduce the susceptibility of the base to loss of the water system from hazardous materials dumped into the river, a feasibility study for developing a well field close to the water plant should be conducted. A contractor could estimate by various means, (well log review, seismic survey, test boring) the yield of the aquifer and the quality of the water.

D. If the results of the survey are favorable, a well or wells could be developed, from which water can be pumped into the plant. The groundwater could be mixed with surface water after the sand filters, chlorinated and distributed. One would expect water drawn from the limestone formations said to underlie Loring to be hard (>100 mg/L $CaCO_3$) and could be mixed with the soft (50 mg/L $CaCO_3$) river water to produce an acceptably soft product.

Table 1

Jar Testing Results

Date: 24 June 86
Temp: 70°F
Total Alkalinity: 51 mg/L
Initial pH: 7.22

Trial 1:

Alum (mg/L)	Polymer (mg/L)	Final pH	Turbidity (NTU)	%Turb. Removal
0	0	7.13	12.0	---
10	0.30	6.91	12.0	0.0
25	0.3	6.59	3.0	75.0
50	0.3	6.22	3.0	75.0
75	0.3	5.75	4.2	65.0
100	0.3	4.98	2.5	79.2

Trial 2:

Alum (mg/L)	Polymer (mg/L)	Final pH	Turbidity (NTU)	%Turb. Removal
0	0.0	6.98	12.0	---
10	3.0	6.75	3.4	71.7
25	3.0	6.55	4.5	62.5
50	3.0	6.06	1.6	86.6
75	3.0	5.63	1.3	89.2
100	3.0	4.91	4.5	62.5

Date: 25 June 86
Temp: 69°F
Total Alkalinity: 50 mg/L
Initial pH: 7.02

Trial 1:

Alum (mg/L)	Polymer(mg/L)	Final pH	Turb. (NTU)	TSS (mg/L)	%Turb. Removal
0	0.3	8.35	9.5	0.4	---
10	0.3	6.84	13.0	0.4	-36.8
25	0.3	6.78	14.0	0.7	-47.4
50	0.3	6.65	3.0	0.4	68.4
75	0.3	6.31	1.3	0.3	86.3
100	0.3	5.84	3.2	0.4	66.3

Trial 2:

Alum (mg/L)	Polymer(mg/L)	Final pH	Turb. (NTU)	TSS (mg/L)	%Turb. Removal
0	0.03	7.74	8.2	0.8	---
10	0.03	7.56	11.0	0.9	-34.1
25	0.03	7.26	16.0	1.6	-95.1
50	0.03	6.83	2.5	0.4	69.5
75	0.03	6.44	1.6	0.4	80.5
100	0.03	5.97	3.5	0.0	57.3

Date: 25 June 86
Temp: 70°F
Total Alkalinity: 25 mg/L
Initial pH: 6.45

Alum (mg/L)	Polymer (mg/L)	Final pH	Turbidity (NTU)	% Turb. Removal
0	0.0	6.45	17.0	---
10	0.3	6.32	5.7	66.4
25	0.3	6.09	6.0	64.7
50	0.3	5.49	4.9	71.2
75	0.3	5.03	6.8	60.0
100	0.3	4.00	8.4	50.6

Date: 25 June 86
Temp: 70°F
Total Alkalinity: 47 mg/L
Initial pH: 7.35

Alum (mg/L)	Polymer (mg/L)	Final pH	Turbidity (NTU)	% Turb. Removal
0	0.0	7.39	17.0	---
10	0.3	7.21	5.9	65.3
25	0.3	6.96	7.4	56.5
50	0.3	6.55	1.3	92.4
75	0.3	6.21	4.0	76.5
100	0.3	5.72	5.7	66.5

Date: 26 June 86
Temp: 68°F
Total Alkalinity: 47 mg/L
Total Hardness: 75

Trial 1:

Alum (mg/L)	Polymer (mg/L)	Final pH	Turbidity (NTU)	% Turb. Removal
0	0.0	7.83	3.0	---
10	0.3	7.52	4.0	-44.4
25	0.3	7.15	4.7	-56.6
50	0.3	6.70	1.5	50.0
75	0.3	6.36	1.0	66.6
100	0.3	5.95	1.7	43.3

Trial 2:

0	0.0	7.48	3.1	---
10	0.3	7.41	3.5	-52.2
25	0.3	7.06	6.8	-195.6
50	0.3	6.63	1.3	43.5
75	0.3	6.26	1.1	52.2
100	0.3	5.70	2.8	-21.7

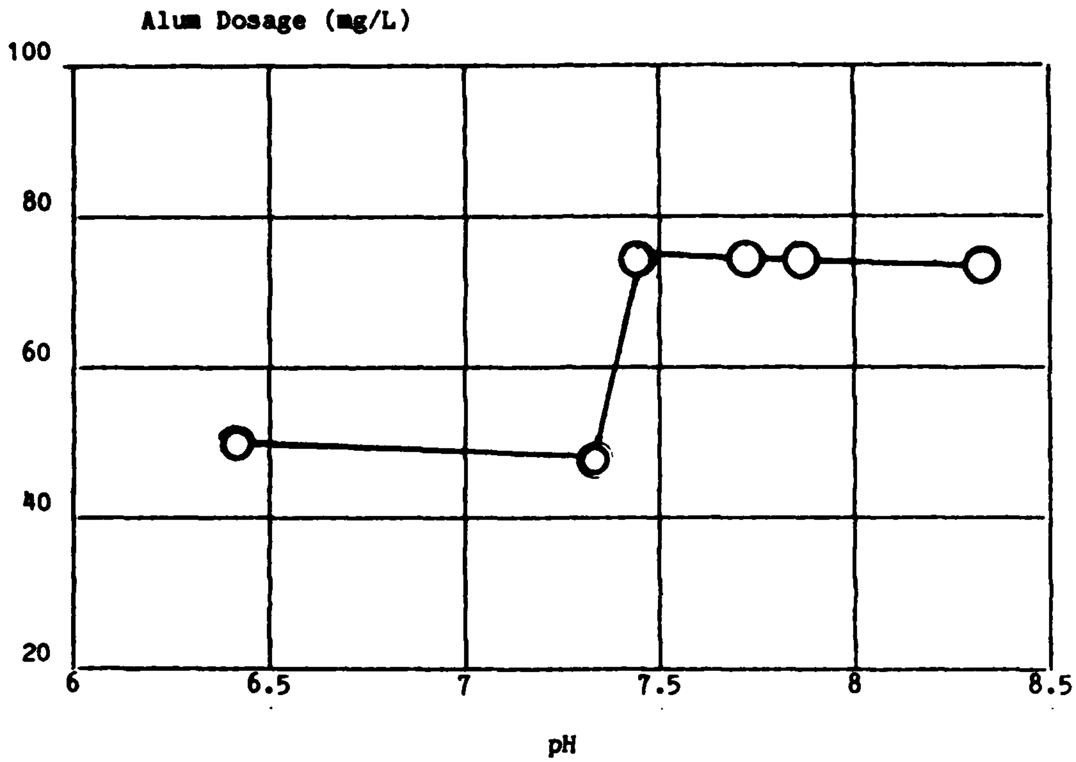

Figure 1: Optimum Alum Coagulant Dosage (mg/L)

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